National Spatial Data Infrastructure

Draft Content Standards for Digital Orthoimagery

Subcommittee on Base Cartographic Data

Federal Geographic Data Committee

January 1997

Federal Geographic Data Committee

Established by Office of Management and Budget Circular A-16, the Federal Geographic Data Committee (FGDC) promotes the coordinated development, use, sharing, and dissemination of geographic data.

The FGDC is composed of representatives from the Departments of Agriculture, Commerce, Defense, Energy, Housing and Urban Development, the Interior, State, and Transportation; the Environmental Protection Agency; the Federal Emergency Management Agency; the Library of Congress; the National Aeronautics and Space Administration; the National Archives and Records Administration; and the Tennessee Valley Authority. Additional Federal agencies participate on FGDC subcommittees and working groups. The Department of the Interior chairs the committee.

FGDC subcommittees work on issues related to data categories coordinated under the circular. Subcommittees establish and implement standards for data content, quality, and transfer; encourage the exchange of information and the transfer of data; and organize the collection of geographic data to reduce duplication of effort. Working groups are established for issues that transcend data categories.

For more information about the committee, or to be added to the committee's newsletter mailing list, please contact:

Federal Geographic Data Committee Secretariat
c/o U.S. Geological Survey
590 National Center
Reston, Virginia 20192

Telephone: (703) 648-5514
Facsimile: (703) 648-5755
Internet (electronic mail): gdc@usgs.gov
Anonymous FTP: ftp://fgdc.er.usgs.gov/pub
World Wide Web: http://fgdc.er.usgs.gov/fgdc.html

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A complete and current copy of the "Content Standards for Digital Orthoimagery" consists of the pages (and most recent creation or revision dates) listed below.

1. INTRODUCTION

1.1 Objective

The objective of this standard is to define the orthoimage theme of the digital geospatial data framework as envisioned by the FGDC. It is the intent of this standard to set a common baseline that will ensure the widest utility of digital orthoimagery for the user and producer communities through enhanced data sharing and the reduction of redundant data production**.** The framework will provide a base on which to collect, register, and integrate digital geospatial information accurately. Digital orthoimagery is a part of this basic set of data described as framework data.

This standard is intended to facilitate the interchange and use of digital orthoimage data under the framework concept. Because of rapidly changing technologies in the geospatial sciences, this standard for digital orthoimagery covers a range of specification issues, many in general terms. This document also describes quality control and standards for testing orthoimage data.

1.2 Maintenance

The U.S. Department of the Interior, United States Geological Survey (USGS), National Mapping Division, maintains the Content Standards for Digital Orthoimagery for the Federal Geographic Data Committee. Address questions concerning this standard to: Chief, National Mapping Division, USGS, 516 National Center, Reston, VA 20192.

1.3 Scope

The standard will describe processing, accuracy, reporting, and applications considerations for digital orthoimagery. This standard is classified as a **Data Content Standard** by the Federal Geographic Data Committee Standards Reference Model. Data content standards provide semantic definitions of a set of objects, such as those described above.

1.4 Relationship to Existing Standards

Throughout this text there are numerous references to metadata and the FGDC's "Content Standard for Digital Geospatial Metadata" (FGDC, 1994). Whenever a comment about metadata appears, the location of the data element description in that standard, placed in parentheses ( ), will follow, or passages will be pointed to from the USGS Digital Orthophoto Quadrangle (DOQ) metadata example in Appendix A. This document will also reference the Spatial Data Transfer Standards (Dept. of Commerce, 1992), the

National Map Accuracy Standard (U.S. Bureau of the Budget, 1947), and the draft FGDC National Standard for Spatial Data Accuracy (FGCS,1996).

1.5 Standards Development Procedures

The draft Content Standards for Digital Orthoimagery have been developed by the Subcommittee on Base Cartographic Data of the FGDC. The development of this standard is guided by the FGDC Standards Reference Model. The Standards Reference Model, developed by the Standards Working Group of the FGDC, provides guidance to FGDC subcommittees for the standards development process. The model also defines the expectations of FGDC standards, describes different types of geospatial standards, and documents the FGDC standards process.

2. DATA DESCRIPTION

A digital orthoimage is a georeferenced image prepared from a perspective photograph or other remotely-sensed data in which displacement of objects due to sensor orientation and terrain relief have been removed. It has the geometric characteristics of a map and the image qualities of a photograph. Digital orthoimages are composed of an array of georeferenced pixels that encode ground reflectance as a discrete value. Digital orthoimagery comes from various sources and in a number of formats, spatial resolutions, and areas of coverage. Many geographic features, including some in other framework data themes, can be interpreted and compiled from an orthoimage. Accurately positioned, high resolution data are considered the most useful to support the compilation of framework features.

3. DIGITAL ORTHOIMAGE STRUCTURE

Framework digital orthoimages shall consist of two-dimensional arrays of pixels, which correspond to ground areas called ground resolution cells. The pixels shall be arranged in horizontal rows (lines) and vertical columns (samples). The order of the rows shall be from top to bottom; the order of columns shall be from left to right. The uppermost left-hand pixel shall be designated pixel 0,0. Each line of image pixels represents a physical record in the file with the total set of records constituting a single file. Images describing more than 1 band of electromagnetic radiation (true color, color-infrared, multi-band) shall be stored in one of three formats: band-interleaved by line (BIL), band interleaved by pixel (BIP), or band sequential (BSQ).

The image shall be a quadrilateral whose image record lengths are identical regardless of its original shape, size or projection. A rectangular or squared image may be accomplished by padding the image with over edge image or non-image pixels, with digital number (DN) equal to zero (black), to an edge defined by the extremes of the image. The bounding coordinates of the image must be documented in accordance with the FGDC "Content Standard for Digital Geospatial Metadata." For images that contain over edge imagery or are padded with non-image pixels, descriptions of both the specific area of interest and any over edge or boundary imagery must be documented by the metadata standard. For instance, USGS digital orthophoto quadrangles include over edge imagery beyond the boundaries of the 7.5- or 3.75-minute image areas. Therefore, USGS is obliged to describe the extent of both the image quadrangle proper (the 3.75- or 7.5-minute quadrangle areas) and that area plus the over-edge. See APPENDIX A: Example of an FGDC Metadata File for a USGS Digital Orthophoto Quarter-quadrangle, (Spatial_Domain/Bounding_Coordinates and Data_Quality_Information/ Attribute_Accuracy/Completeness_Report).

3.1 Image Radiometry

Relative irradiance of ground resolution cells are described by numerical representations (DNs or brightness values) of reflected radiance amplitudes. The cell value is recorded as a series of binary digits or bits, with the number of bits per cell determining the radiometric resolution of the image. Brightness values are commonly represented as 8-bit binary numbers with a range of values from zero (black) to 255 (white).

4. DATA TRANSFER FORMATS

Data transfer formats for digital orthoimagery will not be specified in this standard. However, data producers are encouraged to use the Raster Profile (draft) of the Spatial Data Transfer Standard (SDTS) as the model for formatting their digital orthoimages. As Federal Information Processing Standard 173, SDTS is a requested minimum for Federal data producers. The SDTS was developed in order to help reduce technical barriers to data sharing. While other data transfer formats are permitted, data producers are encouraged to employ the more widely used and accepted raster image formats. The "Content Standards for Digital Spatial Metadata" contains a list of many of the more recognized formats. In all cases, it will be necessary for producers to provide detailed descriptions of the format. Copies of the "Spatial Data Transfer Standard" (Department of Commerce, 1992) are available from:

National Technical Information Service

U.S. Department of Commerce

Springfield, VA 22161

or are available on the World Wide Web at:

ftp://sdts.er.usgs.gov/pub/sdts/standard/

4.1 Non-image data

Image files may contain non-image data in the form of header or trailer records which are physically attached to the image data. These records offer information used to identify, georeference, and impart other information about the data. They are generally in a different format than the image data. Producers of imagery shall document pertinent information about these records: e.g., their location, byte counts, etc., in the metadata. See Section 13. METADATA.

5. SOURCES

Source imagery for digital orthoimages is collected by a variety of remote sensors and processed in a number of ways. All sources employed in the construction of digital orthoimages shall be identified in the metadata (Data_Quality Information/Lineage/Source_Information)

In general, the data needed to create an orthoimage are:

- an unrectified raster image file, from scanned aerial photographs or other remote sensing instruments
- digital elevation data that covers the same area as the image
- ground control
- calibration information about the sensor

These four inputs are used collectively to register the raw image file mathematically to the scanner or to the sensor platform, to determine the orientation and location of the sensor platform with respect to the ground, and to remove the relief displacement from the image file.

Remote sensing systems can be divided into two general categories: imaging and non-imaging. This standard focuses on imaging systems. Five main groups of imaging systems exist: 1)photo-optical, 2)electro-optical, 3)passive microwave, 4)radar, and 5)sonar.

5.1 Seasonal and Time-of-Day Considerations

The season of the year and the time of day when images are acquired can be significant factors to the utility of the imagery. Users engaged in the mapping of terrain features generally prefer the spring and fall "leaf off" seasons with little or no snow cover, while users engaged in vegetation analyses prefer imagery gathered during the growing or "leaf on" season. Similar considerations are true with respect to the time of day imagery is acquired, as for enhanced shadow requirements. Recognizing the variability of user needs, this standard will not specify the times or seasons the source imagery shall be acquired. The date that the imagery was acquired, and the time of day, if it is an important consideration for acquisition, will be indicated in the metadata.
(Lineage:Source_Information/Source_Time_Period_of_Content/Calendar_Date)
For example, if the contract specifications for source photography require enhanced shadow effect, that would be an important consideration outside the usual aerial photography specifications.

5.2 Aerial Photography

Aerial photography is the primary image source currently used to produce digital orthoimages. Film types for orthoimages compliant with the standard shall be confined to black and white (panchromatic), color infrared (CIR), and natural (true) color. Black and white orthoimages may be generated from CIR and natural color source. For aerial photo identification, the type of film, manufacturer or agency identification, and roll and exposure number shall be cited in the metadata.
(Lineage:Source_Information/Source_Citation)

5.2.1 Scanned images from aerial photography

The combination of the Instantaneous Field Of View (IFOV) of the scanner and the scale of the source imagery shall determine the pixel ground resolution which can be attained for the digital orthoimage (Pratt, 1978). Resampling to a pixel ground resolution greater than that of the original scan is acceptable and, in many cases desirable, to create smaller file sizes. Excessive subsampling to attain a pixel ground resolution value less than that of the source imagery is discouraged. (See Section 8. Resolution: Pixel Ground Resolution)

5.3 Electro-optical Images

Electro-optical imaging instruments are non-film detectors which typically use two-dimensional detector arrays of charge-couple devices (CCDs). Each detector in the array is the equivalent of one pixel in the image. At the present, because of the relatively small size of the arrays, electro-optical instruments such as digital cameras are more suited for capturing large scale images with ground sample distances measuring in the sub-meters. Appropriate information about the device, type, array size, pixel resolution, and flight height, will be cited in the image metadata.
(Data_Quality_ Information /Lineage/Process_Step/Process_Description)

5.4 Elevation Data

Elevation data used to correct displacement shall be sufficiently accurate to ensure the image meets National Map Accuracy Standards (NMAS) for the intended scale. Producers of digital orthoimagery shall use elevation data with the appropriate ground sample distances and areal coverage to reliably describe the terrain and meet the accuracy requirements of the image. A detailed description of the source Elevation Model shall be contained in the digital orthoimage metadata.
(Lineage:Source_Information/Source_Citation)
For more information on elevation data refer to the FGDC "Content Standards for Digital Elevation Data" (draft 1/97).

5.5 Control

Ground control from surveyed ground targets and control points established in aerotriangulation (AT) shall be sufficient to meet the accuracy requirements of the intended resolution of the digital orthoimage. Control acquired from maps or other similarly inaccurate methods is not recommended for large-scale digital orthoimages. A description of the methods used to establish control should be cited in the metadata.
(Data_Quality_Information/Positional_Accuracy/Horizontal_Positional_Accuracy/Horizontal_Positional_Accuracy_Report)

5.6 Calibration Data

While camera or imaging instrument calibration parameters are required for production purposes, specifications for that data will not be covered by this standard. Information on camera calibration can be found in the USGS publication "USGS Aerial Camera Specifications" (10/93).

6. AREAL EXTENT

This standard places no constraints on the geographic extent of orthoimages. Areal extent of quadrilateral ortho-images may be adjusted as appropriate for the type of sensor and sensor platform, height, requirements of the user, etc. However, it is recommended that producers of digital orthoimagery data utilize a widely used or familiar partitioning scheme. Numerous established schemes exist for partitioning the Earth's surface. The USGS 7.5-minute topographic map series utilizes one such method. Schemes based upon subsets of the 7.5-minute topographic map could be used for large-scale image partitioning schemes. Other examples include tiles based on the Public Land Survey System (PLSS) or other cadastral systems based on county boundaries, tax plats, etc.

The spatial domain of an image shall be described in the metadata (Identification_Information/Spatial_Domain).

7. GEOREFERENCING

A common means of referencing coordinate positions on the Earth is essential for joining and integrating framework data. It is highly desirable that framework data be described by **longitude and latitude coordinates,** as this system can be readily converted to map projections and grid coordinate systems and promotes the concept of a seamless database. For framework elevation data the default reference for horizontal datum shall be to the **North American Datum of 1983 (NAD83)**. In recognition of significant application of other widely accepted datums throughout the digital geospatial community, other datums may be referenced. In any case, it is important to document the reference datum in the metadata. The horizontal datum shall be described in the metadata:
(Spatial_Reference_Information/Horizontal_Coordinate_System_Definition/Geodetic_Model)

Other commonly recognized coordinate systems include:

- Universal Transverse Mercator (UTM) grid system, and
- State Plane Coordinate System (SPCS).

If data are not described by latitude and longitude, it is highly desirable that they employ one of these coordinate systems. The horizontal coordinate system of the image shall be precisely described in the metadata file: (Spatial_Reference_ Information/Horizontal_Coordinate_System_Definition).

Georegistration of the image is also essential to complete georeferencing of the image. Georegistration will be described by a 4-tuple in the metadata which will establish the position of the first pixel in the first row of the image [pixel (0,0)]. The metadata will reflect the row # = 0, column # = 0, and georeference values in X and Y for the documented datum and horizontal coordinate system. This establishes the georegistration at one point in the orthoimage. Since row and column offsets are both constant and known, (XY_pixel resolution), all other points can be georegistered. Georegistration of pixel (0,0) shall be precisely described in the metadata:
(TBD- not currently included in FGDC Standards for Geospatial Metadata)

8. RESOLUTION

Two separate resolution measurements are important for image data: pixel ground resolution, which is sometimes referred to as horizontal ground resolution or ground sample distance, and radiometric resolution. For this standard, pixel ground resolution defines the area of the ground represented in each pixel in x and y components, while radiometric resolution defines the sensitivity of a detector to differences in wavelength as it records radiant flux reflected or emitted from the ground.

8.1 Pixel Ground Resolution

Images may be resampled to create coarser resolution images than the original raster data. Subsampling of images may be applied only within the limits defined by the Nyquist theorem (Pratt, 1978). The Nyquist frequency limits subsampling to two times (2X) to avoid undesirable aliasing.
The pixel ground resolution shall be recorded in the metadata:
(Spatial_Reference_Information/Horizontal_Coordinate_System_Definition/Planar/Planar_Coordinate_Information).

8.2 Radiometric Resolution

Black and white image data shall be represented as 8-bit binary data. Color images shall be represented as 24-bit, 3 byte data. Digital numbers, or image brightness values shall be represented by 256 gray levels and represented by a number in a range of 0-255. A value of zero shall represent the color black and a value of 255, the color white. All intermediate values are shades of gray varying uniformly from black to white. Areas where the image is incomplete shall be represented with a numeric value of zero.

9. ACCURACY

Framework digital orthoimages shall meet the horizontal accuracy requirements established by National Map Accuracy Standards (NMAS) for the stated scale of the data, or meet user defined accuracy requirements derived for the stated purpose of the data set. NMAS states that 90 percent of the well-defined points tested must fall within 1/50 inch at publication scales smaller than 1:20,000 and 1/30 inch for publication scales larger than 1:20,000. The accuracy of an image is affected by a number of factors: photo scale, ground control, camera characteristics and the elevation data used to rectify the image. Therefore the data producers shall ensure that all critical components have known accuracies suitable for the construction of orthoimagery, and that those accuracies are reported in the metadata.

Data producers should note that a new accuracy standard, the National Standard for Spatial Data Accuracy (NSSDA), is being developed by the FGDC which would supersede NMAS and may impact accuracy requirements for Framework digital orthoimagery. In general, the proposed NSSDA sets new accuracy labeling requirements and means for assessing horizontal data accuracy based on a 95 percent confidence circle.

It is highly recommended that the producers of digital orthoimages include a horizontal positional accuracy report for each image (Data_ Quality_Information/Positional_Accuracy/Horizontal_Positional _Accuracy). The FGDC "Content Standards for Digital Geospatial Metadata" establishes a **mandatory if applicable** requirement for horizontal positional accuracy data. This should not be misconstrued as an optional data element. By definition, an orthoimage exhibits geometric qualities which distinguish it from unrectified imagery, hence accurate measurements can be made from a digital orthoimage and features on the orthoimage will be correctly geopositioned. The accuracy characteristics of a digital orthoimage are usually tested during production or post-production and and recorded in a report on the positional quality and the assessment process. Recommendations on information to be reported and tests to be performed are found in chapter 3 of part 1, Spatial Data Quality, of the Department of Commerce, 1992, "Spatial Data Transfer Standard " (Federal Information Processing Standard 173): Washington, Department of Commerce, National Institute of Standards and Technology.)

10. DATA QUALITY

Different orthoimage production systems have unique characteristics, however all accept raw (or unprocessed) imagery which contain some degree of error in geometry (geometric distortion) and in the measured brightness values of the pixels (radiometric distortion). Image rectification and restoration are processes for correcting distortions and degradations which result from image acquisition. This standard requires specification of rectification or restoration procedures only in context of geometric and radiometric corrections.

Detailed descriptions the processes used to correct distortions in an image shall be made available in the metadata (Data_Quality_ Information /Lineage/Process_Step/Process_Description).

10.1 Geometric Correction

All systematic and random errors shall be removed to the extent required to meet map accuracy standards for the intended scale. Geometric corrections are performed to match raw image data to map geometry. Distortions can be classified as either systematic (predictable errors that follow some definite mathematical or physical law or pattern associated with particular processes and instruments) or random (errors that are wholly due to chance and do not recur). Systematic errors will not be discussed because of their predictable nature and relative ease of correction.

Most of the distortions associated with orthoimages are random. Terrain relief, platform position, and faulty elevation data are the sources of nonsystematic distortion, or random errors. These random errors can be detected by comparing identifiable points on an image to their known ground coordinates. Nearest neighbor, bilinear interpolation, and cubic convolution resampling algorithms are common methods used to transform image values to fit map geolocation values. Nearest neighbor resampling is not recommended for the large-scale framework because of the disjointed appearance in the output due to spatial offsets as great as one-half pixel. Images transformed using bilinear interpolation are generally acceptable. A precise resampling method such as cubic convolution is recommended. Most importantly, the resampling process utilized in the production of the image must be documented in the metadata (Data_Quality_Information /Lineage/Process_Step/Process_Description).

10.1.1 <u>Image smear</u>

Occasionally, because of spikes in the elevation data or excessive topographic relief, an anomaly or artifact best described as an "image smear" may appear on a rectified image. Basically, the steepness of the terrain is such that some ground image is effectively hidden from view (e.g. on the backside of the mountain or the sides of a steep cliff). This can be especially prominent near the edge of images from large-scale aerial photography (incidence of the anomaly decreases as the altitude of the sensor platform increases). When that portion of the scanned raster image is adjusted to its conjugate area on the elevation model, the void in the image is assigned brightness values via an interpolation algorithm which uses the visible image surrounding the void. This sometimes results in a "smeared" or "stretched" area on the image.

When image smears occur, all reasonable means to correct them shall be applied. The elimination of elevation spike error can easily correct this defect. The potential value to be added to the image when attempting to correct stretched or smeared artifacts caused by extensive relief should be weighed against the amount of smearing, the time and effort investment to correct the artifact and affected features, and the intended use of the image. It may not be cost-effective or necessary to correct all image smear artifacts. Quantifying the amount of acceptable smearing in a image is a subjective matter and until reliable methods to assess the location and amount of smearing are established, determination of the acceptability of an image will be by visual inspection. Images shall be rejected for remake or recollection when artifacts appear in areas where manmade planimetric features are evident, or in areas where significant natural features appear or, if artifacts are of such an extent to render the image unusable.

10.1.2 Other elevation-related geometric distortions.

Double or missing features in the image are indications of a poor Elevation Model or unsuitable control and shall be corrected.

10.2 Radiometric Correction

Image brightness values may deviate from the brightness values of the original imagery, due to image value interpolation during the scanning, rectification, and post-processing procedures. However, data producers are cautioned to minimize the amount of radiometric correction applied to an image. The image brightness values of a processed image should reflect the source imagery as closely as possible. It is common practice to perform some radiometric enhancements and corrections (e.g., contrast stretching, analog dodging, noise filtering, destriping, edge matching) to images prior to release of the data. Data producers shall use processing techniques which minimize data loss from the time the information was captured until its release to the users. Any image restoration or enhancement processes applied to an image shall be reported in the metadata (Data_Quality_Information/Lineage/Process_Step/Process_Description).

Radiometric accuracy can be verified by visual comparison of the digital orthoimage with the original unrectified image to determine if the digital orthoimage has the same or better image quality as the original unrectified input image(s). Radiometric accuracy verification process and results shall be reported in the metadata (Data_Quality_Information:Attribute_Accuracy/Attribute_Accuracy_Report).

11. DATA COMPLETENESS

Visual verification shall be performed for image completeness, to ensure that, whenever possible, no gaps exist in the image area. Images that are not complete shall report those omissions in the metadata (Data_Quality_Information/Completeness_Report).

11.1 Cloud Cover

An image containing more than 10 percent cloud coverage is classified not complete. However, for some areas of an image (e.g. over broad bodies of water) cloud cover may be deemed acceptable to some users. Therefore, imagery with more than 10 percent cloud cover is allowed by exception under this specification. The percentage of cloud cover obstruction shall be recorded in the in the metadata (Data_Quality_Information/Cloud_Cover).

12. IMAGE MOSAICKING

Mosaicking of multiple images to create a single orthoimage is permitted. Temporal and seasonal differences between image chips shall be minimized to avoid incongruence across join lines. When a mosaic of two or more digital orthoimage chips is made, the chip judged by visual inspection to have the best contrast shall be used as the reference image. The brightness values of the other chips shall be adjusted to match that of the reference chip. The join lines between the overlapping chips shall be chosen so as to minimize tonal variations. Localized adjustment of the brightness values shall be performed to minimize tonal differences between join areas. Identification of the multiple sources as well as the extent of each chip of a mosaicked image shall be described in the metadata : (Data_Quality_Information/Lineage/Source_ Information/Source_Citation).

13. METADATA

The FGDC emphasizes the importance of good metadata, to provide quality information about data which will allow users to match data to their needs. This standard describes a general set of specifications, and as such, places most of the burden on the user to assess quality and applicability of data. Appropriate metadata facilitates this process. Certainly, for the user, data with documentation is more useful than data that has none. The more high quality metadata there is for a product, the more it can support the user’s determination of its reliability, quality, and accuracy. Metadata is intended to be of value to the producer as well as to the user.

The FGDC’s "Content Standards for Digital Geospatial Metadata" will be the source for all issues relating to terminology and definitions relating to metadata. Executive Order 12906 "Coordinating Geographic Data Acquisition and Access: The National Spatial Data Infrastructure," requires all Federal agencies to use the standard to document data that they produce beginning in 1995. For more information about the FGDC and the Content Standard for Digital Geospatial Metadata, contact:

Federal Geographic Data Committee Secretariat
c/o U.S. Geological Survey
590 National Center
Reston, Virginia 20192

Telephone: (703) 648-5514
Facsimile (703) 648-5775
Internet(electronic mail): gdc@usgs.gov
Anonymous FTP: ftp://fgdc.er.usgs.gov
World Wide Web (WWW): http://fgdc.er.usgs.gov/fgdc.html

Appendix A; contains an example of a metadata file for a specific orthoimage. The example cited is for a USGS digital orthophoto quarter-quadrangle.

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Appendix A

Example of an FGDC Metadata File for a USGS Digital Orthophoto Quarter-quadrangle

This appendix describes a specific USGS digital orthophoto quarter quadrangle (Washington West SE) with it's metadata. The following text illustrates a file specific level implementation of the "Content Standards for Digital Geospatial Metadata"(6/8/94). Numbers preceding element names indicate the location of the element definition in the metadata standard. Element names are in bold type.

1. **Identification_Information**:

1.1 **Citation**:

8.1 **Originator**: WMC U.S. Geological Survey

8.2 **Publication_Date**: 19930608

8.4 **Title**: Washington West SE

8.6 **Geospatial_Data_Presentation_Form:** remote-sensing image

8.8 **Publication_Information:**

8.8.1 **Publication_Place**: Reston, VA

8.8.2 **Publisher:** U.S. Geological Survey

1.2 **Description:**

1.2.1 **Abstract:**

A digital orthophoto is a raster image of remotely sensed data in which displacement in the image due to sensor orientation and terrain relief have been removed. Orthophotos combine the image characteristics of a photograph with the geometric qualities of a map. The primary digital orthophotoquad (DOQ) is a 1-meter ground resolution, quarter-quadrangle (3.75-minutes of latitude by 3.75-minutes of longitude) image cast on the Universal Transverse Mercator Projection (UTM) on the North American Datum of 1983 (NAD83). The geographic extent of the DOQ is equivalent to a quarter-quad plus overedge. The overedge ranges a minimum of 50 meters to a maximum of 300 meters beyond the extremes of the primary and secondary corner points. The overedge is included to facilitate tonal matching for mosaicking and for the placement of the NAD83 and secondary datum corner ticks. The normal orientation of data is by lines (rows) and samples (columns). Each line contains a series of pixels ordered from west to east with the order of the lines from north to south. The standard, archived digital orthophoto is formatted as four ASCII header records, followed by a series of 8-bit binary image data records. The radiometric image brightness values are stored as 256 gray levels ranging from 0 to 255. The metadata provided in the digital orthophoto contain a wide range of descriptive information including format source information, production instrumentation and dates, and data to assist with displaying and georeferencing the image. The standard distribution format of DOQs will be JPEG compressed images on CD-ROM by counties or special regions. The reconstituted image from the CD-ROM will exhibit some radiometric differences when compared to its uncompressed original but will retain the geometry of the uncompressed DOQ. Uncompressed DOQs are distributed on tape.

1.2.2 **Purpose:**

DOQ's serve a variety of purposes, from interim maps to field references for earth science investigations and analysis. The DOQ is useful as a layer of a geographic information system and as a tool for revision of digital line graphs and topographic maps.

1.3 **Time_Period_of_Content:**

9.1 **Single Time/Date:**

9.1.1 **Calendar Date**: 19930514

1.3.1 **Currentness_Reference**: ground condition

1.4 **Status:**

1.4.1 **Progress**: Complete

1.4.2 **Maintenance_and_Update_Frequency**: Irregular

1.5 **Spatial_Domain**:

1.5.1 **Bounding_Coordinates**:

1.5.1.1 **West_Bounding_Coordinate**: -077.0625

1.5.1.2 **East_Bounding_Coordinate**: -077.00

1.5.1.3 **North_Bounding_Coordinate**: 38.9375

1.5.1.4 **South_Bounding_Coordinate**: 38.875

1.6 **Keywords:**

1.6.1 **Theme:**

1.6.1.1 **Theme_Keyword_Thesaurus:** None

1.6.1.2 **Theme_Keyword:** DOQ

1.6.1.2 **Theme_Keyword**: DOQQ

1.6.1.2 **Theme_Keyword**: digital orthophoto

1.6.1.2 **Theme_Keyword**: digital orthophotoquad

1.6.1.2 **Theme_Keyword**: digital image map

1.6.1.2 **Theme_Keyword**: aerial photograph

1.6.1.2 **Theme_Keyword**: rectified photograph

1.6.1.2 **Theme_Keyword**: rectified image

1.6.1.2 **Theme_Keyword**: orthophoto

1.6.1.2 **Theme_Keyword**: quarter-quadrangle orthophoto

1.6.1.2 **Theme_Keyword**: 1-meter orthophoto

1.6.1.2 **Theme_Keyword**: 2-meter orthophoto

1.6.1.2 **Theme_Keyword**: 3.75- x 3.75-minute orthophoto

1.6.1.2 **Theme_Keyword**: 7.5- x 7.5-minute orthophoto

1.6.2 **Place:**

1.6.2.1 **Place_Keyword_Thesaurus**:

U.S. Department of Commerce, 1977, Countries, dependencies, areas of special sovereignty, and their principal administrative divisions (Federal Information Processing Standard 10-3):Washington, D.C., National Institute of Standards and Technology.

1.6.2.2 **Place_Keyword**: US

1.6.2.1 **Place_Keyword_Thesaurus**:

U.S. Department of Commerce, 1987, Codes for the identification of the States, the District of Columbia and the outlying areas of The United States, and associated areas (Federal Information Processing Standard 5-2): Washington, D. C., National Institute of Standards and Technology.

1.6.2.2 **Place_Keyword**: DC

1.6.2.2 **Place_Keyword**: VA

1.6.2.1 **Place_Keyword_Thesaurus:**

U.S. Department of Commerce,1990, Counties and equivalent entities of The United States, its possessions, and associated areas (Federal Information Processing Standard 6-4): Washington, D.C. National Institute of Standards and Technology.

1.6.2.2 **Place_Keyword:** 001

1.6.2.2 **Place_Keyword**: 013

1.7 **Access_Constraints:** None

1.8 **Use_Constraints**: None. Acknowledgment of the U.S. Geological Survey would be appreciated in products derived from these data.

1.13 **Native_Data_Set_Environment:** DV1.2 03/94 OV1.1 04/93 bytes=47702272

2. **Data_Quality_Information**

2.1 **Attribute_Accuracy**:

2.1.1 **Attribute_Accuracy_Report**:

During photographic reproduction of the source photography, limited analog dodging is performed to improve image quality. Analog dodging consists of holding back light from certain areas of the sensitized photographic material to avoid overexposure. The diapositive is inspected to insure clarity and radiometric uniformity. Diapositive image brightness values are collected with a minimum of image quality manipulation. Image brightness values may deviate from brightness values of the original imagery due to image value interpolation during the scanning and rectification processes. Radiometry is verified by visual inspection of the digital orthophoto quadrangle with the original unrectified image to determine if the digital orthophoto has the same or better image quality as the original unrectified input image. Slight systematic radiometric differences can be detected between adjacent DOQ files due primarily to differences in source photography capture dates and sun angles of aerial photography along flight lines. These differences can be observed in an image's general lightness or darkness when compared to adjacent DOQ file coverages.

2.2 **Logical_Consistency_Report**:

All DOQ header data and image file sizes are validated by the Tape Validation System (TVS) software prior to archiving in the National Digital Cartographic Data Base (NDCDB). This validation procedure assures correct physical format and field values for header record elements. Logical relationships between header record elements are tested.

2.3 **Completeness_Report**:

All DOQ imagery is visually inspected for completeness to ensure that no gaps, or image misplacement exists in the 3.75' image area or in overedge coverage. DOQ images may be derived by mosaicking multiple images, in order to insure complete coverage. All DOQ's are cloud free within the 3.75' image area. Some clouds may, very infrequently, be encountered only in the overedge coverage. Source photography is leaf-off in deciduous vegetation regions. Void areas having a radiometric value of zero and appearing black may exist. These are areas for which no photographic source is available or result from image transformation from other planimetric systems to the Universal Transverse Mercator (UTM). In the latter case, the void sliver areas are on the outside edges of the overedge area. The data set field content of each DOQ header record element is validated to assure completeness prior to archiving in the NDCDB.

The area of coverage for a standard USGS digital orthophoto is either a quarter-quadrangle (3.75-minutes of latitude by 3.75-minutes of longitude plus overedge) or quadrangle (7.5-minutes of latitude by 7.5-minutes of longitude plus overedge).

USGS requires image overedge to provide overlap coverage between adjoining DOQ's to facilitate edge matching and mosaicking. That overedge extent is 300 (±30) meters beyond the extremes of the primary and secondary datum corner points for the standard digital orthophoto quad.

However, some Federal, State and local agencies, and private entities not associated with the National Digital Orthophoto Program (NDOP) may provide DOQs to the USGS under cooperative agreement programs.

In order to meet the requirements of the NDOP program and include other sources of DOQs, the geographic extent for DOQs shall be:

- o For DOQs produced under National Digital Orthophoto Program funding agreements: 300 (±30) meters minimum beyond the extremes of the primary and secondary datum corner points.
- o For DOQs produced under other cooperative agreements: a minimum of 50 meters beyond the primary and secondary horizontal datum corner point extremes.

The resulting digital orthophoto is a rectangle whose size may vary in relation to adjoining digital orthophotos.

2.4 **Positional_Accuracy**:

2.4.1 **Horizontal_Positional_Accuracy**:

2.4.1.1 **Horizontal_Positional_Accuracy_Report:**

The DOQ horizontal positional accuracy and the assurance of that accuracy depend, in part, on the accuracy of the data inputs to the rectification process. These inputs consist of the digital elevation model (DEM),aerotriangulation control and methods, the photo source camera calibration, scanner calibration, and aerial photographs that meet National Aerial Photography Program (NAPP) standards. The vertical accuracy of the verified USGS format Elevation Model is equivalent to or better than a USGS level 1 or 2 DEM, with a root mean square error (RMSE) of no greater than 7.0 meters. Field control is acquired by third order class 1 or better survey methods sufficiently spaced to meet National Map Accuracy Standards (NMAS) for 1:12,000-scale products. Aerial cameras have current certification from the USGS, National Mapping Division, Optical Science Laboratory. Test calibration scans are performed on all source photography scanners. Horizontal positional accuracy is determined by the Orthophoto Accuracy (ORACC) software program for DOQ data produced by the National Mapping Division. The program determines the accuracy by finding the line and sample coordinates of the passpoints in the DOQ and fitting these to their ground coordinates to develop a root mean square error (RMSE). Four to nine points are checked. As a further accuracy test, the image line and sample coordinates of the DEM corners are transformed and compared with the actual X,Y DEM corner values to determine if they are within the RMSE. Additional information on this testing procedure can be found in U.S. Department of the Interior, U.S. Geological Survey, 1993, TechnicalInstructions, ORACC Users Manual (draft): Reston, VA. Adjacent DOQ's, when displayed together in a common planimetric coordinate system, may exhibit slight positional discrepancies across common DOQ boundaries. Linear features, such as streets, may not be continuous. These edge mismatches, however, still conform to positional horizontal accuracy within the NMAS. Field investigations to validate DOQ positional accuracy reliabilty are periodically conducted by the USGS, National Mapping Division, Geometronics Standards Section. DOQ's produced by cooperators and contractors use similarly approved RMSE test procedures.

2.4.1.2 **Quantitative_Horizontal_Positional_Accuracy_Assessment**:

2.4.1.2.1 **Horizontal_Positional_Accuracy_Value:** 0.8

2.4.1.2.2 **Horizontal_Positional_Accuracy_Explanation**:

U.S.Bureau of the Budget, 1947, United States National Map Accuracy Standard.

2.5 **Lineage**:

2.5.1 **Source_Information**:

2.5.1.1 **Source_Citation:**

8.1 **Originator:** U.S. Geological Survey

8.2 **Publication_Date:** unknown

8.4 **Title:** digital elevation model

8.8 **Publication_Information**:

8.8.1 **Publication_Place**: Reston, VA

8.8.2 **Publisher**: U.S. Geological Survey

2.5.1.3 **Type_of_Source_Media:** cartridge tape

2.5.1.4 **Source_Time_Period_of_Conten**t:

9.1 **Single_Date/Time:**

9.1.1 **Calendar_Date:** 1968

2.5.1.4.1 **Source_Currentness_Reference**: ground condition

2.5.1.5 **Source_Citation_Abbreviation**: DEM1

2.5.1.6 **Source_Contribution**:

Elevation data in the form of an ortho-DEM regridded to user-specified intervals and bounds.

2.5.1 **Source_Information**:

2.5.1.1 **Source_Citation**:

8.1 **Originator**: U.S. Geological Survey

8.2 **Publication_Date**: Unknown

8.4 **Title:** NAPP 4-179

8.6 **Geospatial_Data_Presentation_Form**: remote-sensing image

8.8 **Publication_Information**:

8.8.1 **Publication_Place**: Reston, VA

8.8.2 **Publisher:** U.S. Geological Survey

2.5.1.2 **Source_Scale_Denominator**: 40000

2.5.1.3 **Type_of_Source_Media**: cartridge tape

2.5.1.4 **Source_Time_Period_of_Content:**

9.1 **Single_Date/Time:**

9.1.1 **Calendar_Date**: 19880405

2.5.1.4.1 **Source_Currentness_Reference**: ground condition

2.5.1.5 **Source_Citation_Abbreviation**: PHOTO1

2.5.1.6 **Source_Contribution**: Panchromatic Black and White NAPP

2.5.1 **Source_Information**:

2.5.1.1 **Source_Citation**:

8.1 **Originator:** U.S. Geological Survey

8.2 **Publication_Date:** Unpublished material

8.4 **Title:** project ground and photo control

8.8 **Publication_Informatio**n:

8.8.1 **Publication_Place:** Reston, VA

8.8.2 **Publisher:** U.S. Geological Survey

2.5.1.3 **Type_of_Source_Media**: various media

2.5.1.4 **Source_Time_Period_of_Content**:

9.3 **Range_of_Dates/Times**:

9.3.1 **Beginning_Date**: various

9.3.2 **Ending_Date**: various

2.5.1.4.1 **Source_Currentness_Reference**: ground condition

2.5.1.5 **Source_Citation_Abbreviation**: CONTROL_INPUT

2.5.1.6 **Source_Contribution**:

Horizontal and vertical control used to establish positions and elevations for reference and correlation purposes.

2.5.1 **Source_Information**:

2.5.1.1 **Source_Citation**:

8.1 **Originator**: U.S. Geological Survey

8.2 **Publication_Date:** Unpublished material

8.4 **Title**: report of calibration

8.8 **Publication_Information:**

8.8.1 **Publication_Place**: Reston, VA

8.8.2 **Publisher**: U.S. Geological Survey

2.5.1.3 **Type_of_Source_Media:** disc, paper

2.5.1.4 **Source_Time_Period_of_Content:**

9.3 **Range_of_Dates/Times:**

9.3.1 **Beginning_Date**: various

9.3.2 **Ending_Date:** various

2.5.1.4.1 **Source_Currentness_Reference:**

Date of the camera calibration associated with the source photography

2.5.1.5 **Source_Citation_Abbreviation**: CAMERA_INPUT

2.5.1.6 **Source_Contribution**: camera calibration parameters

2.5.2 **Process_Step:**

2.5.2.1 **Process_Description**:

The production procedures, instrumentation, hardware and software used in the collection of standard USGS DOQ's vary depending on systems used at the contract, cooperator or USGS production sites. The majority of DOQ datasets are acquired through government contract. The process step describes, in general, the process used in the production of standard USGS DOQ data sets.

The rectification process requires a user parameter file as input to control the rectification process, a digital elevation model (DEM1) gridded to user specified bounds, projection, zone, datum and X-Y units, a scanned digital image file (PHOTO1) covering the same area as the DEM, ground X-Y-Z point values (CONTROL_INPUT) and their conjugate photo coordinates in the camera coordinate system, and measurements of the fiducial marks (CAMERA_INPUT) in the digitized image.

The camera calibration report (CAMERA_INPUT) provides the focal length of the camera and the distances in millimeters from the camera's optical center to the camera's 8 fiducial marks. These marks define the frame of reference for spatial measurements made from the photograph. Ground control points (CONTROL_INPUT) acquired from ground surveys or developed in aerotriangulation are third order class 1 or better and meet National Map Accuracy Standard (NMAS) for 1:12,000-scale. Ground control points are in the Universal Transverse Mercator or the State Plane Coordinate System on NAD83. Horizontal and vertical residuals of aerotriangulated tie-points are equal to or less than 2.5 meters. Standard aerotriangulation passpoint configuration consists of 9 ground control points, one near each corner, one at the center near each side and 1 near the center of the photograph, are used. The conjugate positions of the ground control points on the photograph are measured and recorded in camera coordinates.

The raster image file (PHOTO_1) is created by scanning an aerial photograph film diapositive with a precision image scanner. An aperture of approximately 25 to 32 microns is used, with an aperture no greater than 32 microns permitted. Using 1:40,000-scale photographs, a 25-micron scan aperture equates to a ground resolution of 1-meter. The scanner converts the photographic image densities to gray scale values ranging from 0 to 255 for black and white photographs. Scan files with ground resolution less than 1 meter or greater than 1 meter but less than 1.28 meters are resampled to 1 meter.

The principal elevation data source (DEM1) are standard DEM datasets from the National Digital Cartographic Data Base (NDCDB). DEM's that meet USGS standards are also produced by contractors to fulfill DOQ production requirements and are subsequently archived in the NDCDB. All DEM data is equivalent to or better than USGS DEM standard level 1. The DEM used in the production of DOQ's generally has a 30-meter grid post spacing and possesses a vertical RMSE of 7-meters or less. A DEM covering the extent of the photograph is used for the rectification. The DEM is traversed from user-selected minimum to maximum X-Y values and the DEM X-Y-Z values are used to find pixel coordinates in the digitized photograph using transformations mentioned above. For each raster image cell subdivision, a brightness or gray-scale value is obtained using nearest neighbor, bilinear, or cubic convolution resampling of the scanned image. The pixel processing algorithm is indicated in the header file. An inverse transformation relates the image coordinates referenced to the fiducial coordinate space back to scanner coordinate space. For those areas for which a 7.5-minute DEM is unavailable and relief differences are less than 150 feet, a planar-DEM (slope-plane substitute grid) may be used.

<u>Rectification Process</u>: The photo control points and focal length are iteratively fitted to their conjugate ground control points using a single photo space resection equation. From this mathematical fit a rotation matrix of constants about the three axes of the camera is obtained. This rotation matrix can then be used to find the photograph or camera coordinates of any other ground X-Y-Z point. Next a two dimensional fit is made between the measured fiducial marks on the digitized photograph and their conjugate camera coordinates. Transformation constants are developed from the fit and the camera or photo coordinates are used in reverse to find their conjugate pixel coordiates on the digitized photograph.

<u>Quality Control</u>: All data is inspected according to a quality control plan. DOQ contractors must meet DOQ standards for attribute accuracy, logical consistency, data completeness and horizontal positional accuracy. During the initial production phase, all rectification inputs and DOQ data sets are inspected for conformance to standards. After a production source demonstrates high quality, inspections will be made to 10% of delivery lots 40 DOQs per lot). All DOQ's are visually inspected for gross positional errors and tested for physical format standards.

2.5.2.2 **Source_Used_Citation_Abbreviation**: DEM1, PHOTO1, CONTROL_INPUT, CAMERA_INPUT

2.5.2.3 **Process_Date**: 19930514

3. **Spatial_Data_Organization_Information**:

3.2 **Direct_Spatial_Reference_Method**: raster

3.4 **Raster_Object_Information:**

3.4.1 **Raster_Object_Type:** Pixel

3.4.2 **Row_Count:** 7680

3.4.3 **Column_Count:** 6208

4. **Spatial_Reference_Information:**

4.1 **Horizontal_Coordinate_System_Definition:**

4.1.2 **Planar:**

4.1.2.2 **Grid_Coordinate_System**:

4.1.2.2.1 **Grid_Coordinate_System_Name**: Universal Transverse Mercator

4.1.2.2.2 **Universal_Transverse_Mercator**:

4.1.2.2.2.1 **UTM_Zone_Number**: 18

4.1.2.1.2 **Transverse_Mercator**:

4.1.2.1.2.17 **Scale_Factor_at_Central_Meridian**: 0.9996

4.1.2.1.2.2 **Longitude_of_Central_Meridian**: -75.0

4.1.2.1.2.3 **Latitude_of_Projection_Origin**: 0.0

4.1.2.1.2.4 **False_Easting**: 500000.

4.1.2.1.2.5 **False_Northing**: 0.0

4.1.2.4 **Planar_Coordinate_Information**:

4.1.2.4.1 **Planar_Coordinate_Encoding_Method:** row and column

4.1.2.4.2 **Coordinate_Representation**:

4.1.2.4.2.1 **Abscissa_Resolution**: 1

4.1.2.4.2.2 **Ordinate_Resolution**: 1

4.1.2.4.4 **Planar_Distance_Units**: meters

4.1.4 **Geodetic_Model:**

4.1.4.1 **Horizontal_Datum_Name**: North American Datum 1983

4.1.4.2 **Ellipsoid_Name**: Geodetic Reference System 80

4.1.4.3 **Semi-major_Axis**: 6378137

4.1.4.4 **Denominator_of_Flattening_Ratio**: 298.257

5. **Entity_and_Attribute_Information**:

5.2 **Overview_Description:**

5.2.1 **Entity_and_Attribute_Overview**:

For DOQ's from panchromatic source, each pixel contains an 8-bit gray-scale value between 0-255. Zero represents black, while 255 represents white. All values between 0 and 255 represent a shade of gray varying from black to white. For color-infrared and natural color DOQs', a digital number from 0 to 255 will also be assigned to each pixel but that number will refer to a color look-up table which will contain the RGB red, blue and green (RGB) values, each from 0 to 255, for that digital number. Areas where the rectification process is incomplete due to incomplete data (i.e., lack of elevation data, gaps), are represented with the numeric value of 0.

5.2.2 **Entity_and_Attribute_Detail_Citation**:

U.S. Department of the Interior, U.S. Geological Survey, 1992, Standards for Digital Orthophotos: Reston, VA.

A hypertext version is available at:

http://www-nmd.usgs.gov/www/ti/DOQ/standards_doq.html

Softcopy in ASCII format is available at:

ftp://www-nmd.usgs.gov/pub/ti/DOQ/doqstnds/stdoqpt1.txt

ftp://www-nmd.usgs.gov/pub/ti/DOQ/doqstnds/stdoqpt2.txt

Softcopy in WordPerfect format is available at:

ftp//www-nmd.usgs.gov/pub/ti/DOQ/doqstnds/stdoqpt1.wp5

ftp://www-nmd.usgs.gov/pub/ti/DOQ/doqstnds/stdoqpt2.wp5

Softcopy in PostScript format is available at:

ftp://www-nmd.usgs.gov/pub/ti/DOQ/doqstnds/stdoqpt1.ps

ftp://www-nmd.usgs.gov/pub/ti/DOQ/doqstnds/stdoqpt2.ps

6. **Distribution_Information**:

6.1 **Distributor:**

10.2 **Contact_Organization_Primary**:

10.1.2 **Contact_Organization**: Earth Science Information Center, U.S. Geological Survey

10.4 **Contact_Address**:

10.4.1 **Address_Type**: mailing address

10.4.2 **Address:** 507 National Center

10.4.3 **City**: Reston

10.4.4 **State_or_Province**: VA

10.4.5 **Postal_Code**: 20192

10.5 **Contact_Voice_Telephone**: 1 800 USA MAPS

10.9 **Hours_of_Service**: 0800-1600

10.10 **Contact_Instructions:**

In addition to the address above there are other ESIC offices throughout the country. A full list of these offices is at:

http://www-nmd.usgs.gov/esic/esic_index.html

6.2 **Resource_Description**: Digital Orthophotoquad

6.2 **Resource_Description**: DOQ

6.2 **Resource_Description**: DOQQ

6.3 **Distribution_Liability**:

Although these data have been processed successfully on a computer system at the U.S. Geological Survey, no warranty, expressed or implied, is made by the USGS regarding the utility of the data on any other system, nor shall the act of distribution constitute any such warranty. The USGS will warrant the delivery of this product in computer-readable format and will offer appropriate adjustment of credit when the product is determined unreadable by correctly adjusted computer input peripherals, or when the physical medium is delivered in damaged condition. Requests for adjustments of credit must be made within 90 days from the date of this shipment from the ordering site.

6.4 **Standard_Order_Process**:

6.4.2 **Digital_Form**:

6.4.2.1 **Digital_Transfer_Information:**

6.4.2.1.1 **Format_Name**: DOQ

6.4.2.1.5 **Format_Information_Content**:

USGS uncompressed DOQ: The uncompressed USGS DOQ is a raw binary image file preceded by a metadata header record which consists of four 400-byte ACSII records, each blank padded to equal the length of a single line of image data.

6.4.2.2 **Digital_Transfer_Option**:

6.4.2.2.2 **Offline_Option:**

6.4.2.2.2.1 **Offline_Media**: 8-mm helical-scan cartridge tape

6.4.2.2.2.3 **Recording_Format**:

Unlabelled, uncompressed Unix DD archive format. Standard block size: 30,270, but can be provided at 2,048 or multiples of 2,048.

6.4.2.2.2 **Offline_Option**:

6.4.2.2.2.1 **Offline_Media**: 9-track tape

6.4.2.2.2.3 **Recording_Format:**

Unlabelled, uncompressed Unix DD archive format. Blocksize = 6250 cpi.

6.4.2.2.2 **Offline_Option:**

6.4.2.2.2.1 **Offline_Media**: 3480 cartridge tape

6.4.2.2.2.3 **Recording_Format**:

Unlabelled, uncompressed Unix DD archive format. Blocksize = 6250 cpi.

6.4.3 **Fees**:

The online copy of the data set (when available electronically) may be accessed without charge. For 8-mm cartridge and 9-track tapes the costs are:

1 digital product = $40

2 digital products = $60

3 digital products = $80

4 digital products = $100

5 digital products = $120

6 or more = $90 plus $7 per each product over six

6.4 **Standard_Order_Process**:

6.4.2 **Digital_Form**:

6.4.2.1 **Digital_Transfer_Information**:

6.4.2.1.1 **Format_Name:** JPEG

6.4.2.1.5 **Format_Information_Content:**

The USGS compressed DOQ is an IJG JPEG-compressed file. JPEG is a lossy compression technique. Unlike uncompressed DOQ's the compressed DOQ does not contain an attached header record as data compression corrupts ASCII text. A separate metadata file accompanies the compressed image file. The compressed data are distributed on CD-ROM, generally by county.

However, some CD's may contain regions or partial counties and some counties may require multiple CD-ROM's. The presence of a DOQ in the NDCDB does not necessarily indicate the file is available on a compressed, county based CD-ROM.

6.4.2.1.6 **File_Decompression_Technique**:

The algorithm employed by USGS for compressing DOQs is IJG JPEG, Version 4.0. This is a lossy compression using a standard Q or quality factor of 30.

6.4.2.1.7 **Transfer_Size**: 4.5

6.4.2.2 **Digital_Transfer_Option**:

6.4.2.2.1 **Offline_Option:**

6.4.2.2.2.1 **Offline_Media**: CD-ROM

6.4.2.2.2.3 **Recording_Format:** ISO 9660

6.4.2.2.2.4 **Compatibility_Information**:

This CD-ROM can be used with all computer operating systems that support CD-ROM as a logical storage device. All text files on this disc are in ASCII format. Data files are in ASCII or binary format.

6.4.3 **Fees**: The charge is $32 per CD-ROM.

7. **Metadata_Reference_Information**:

7.1 **Metadata_Date**: 19950627

7.4 **Metadata_Contact**:

10.2 **Contact_Organization_Primary**:

10.1.2 **Contact_Organization:** U.S. Geological Survey

10.4 **Contact_Address:**

10.4.2 **Address:** 590 National Center

10.4.3 **City:** Reston

10.4.4 **State_or_Province**: VA

10.4.5 **Postal_Code**: 20192

10.5 **Contact_Voice_Telephone:** 703 648 5514

10.7 **Contact_Facsimile_Telephone:** 703 648 5755

10.8 **Contact_Electronic_Mail_Address:** gdc@usgs.gov

7.5 **Metadata_Standard_Name**: *Content Standards for Digital Geospatial Metadata*

7.6 **Metadata_Standard_Version**: 19940608

Appendix B - Definitions

DEFINITIONS:

Absolute Accuracy - Absolute accuracy is a measure which accounts for all systematic and random errors in a data set. Absolute accuracy is stated with respect to a defined datum or reference system.

Absolute Horizontal Accuracy - Absolute horizontal accuracy is a measure of the positional (planimetric) quality with respect to a reference datum. This measure accounts for all systematic and random errors in the data set.

Band - a range of wavelengths of electromagnetic radiation specified to produce a single response to a sensing device.

Band Interleaved - the ordered mixing of lines (band interleaved by line) or pixels (band interleaved by pixels) of one or more bands with corresponding lines or pixels of other bands, for the purpose of forming a single image file.

Band Sequential (BSQ)- a sequence of one image band followed by another image band. A band sequential file may be formed by appending bands in sequence within a single file.

Bilinear interpolation - the mathematical computation for an unknown value based on the linear interpolation along two axes. The axes are derived using a coordinate transformation algorithm to locate the quadrilateral of the four nearest profile points surrounding the unknown point. The interpolation computes the unknown value based on the average, by use of weights and distances, of the four nearest known values.

Brightness value (Digital Number) - a number representing a discrete gray level in an image.

Cubic Convolution - a mathematical computation for the interpolation of an unknown value based on a third degree polynomial equation using surrounding known values.

Digital Orthoimage - a georeferenced digital image prepared from a perspective photograph, or other remotely-sensed data in which displacement of objects in the image due to sensor orientation and terrain relief have been removed.

Framework - collection of basic geospatial data upon which users may collect, register or integrate geospatial information. Thematic categories comprising the framework include: geodetic control, digital orthoimagery, elevation, transportation, hydrography, governmental units, and cadastre (FGDC,1995) .

Metadata - data about data. Textual information describing the content, quality, condition, and other characteristics of data.

Micron (μ) - the unit of length defined to be 0.000001 meter.

Nearest Neighbor - the mathematical computation for an unknown value based solely on the value of the nearest known value.

Panchromatic (photography) - a term applied to photographic materials possessing sensitivity to all visible spectral colors, including red.

Relative Accuracy - Relative accuracy is a measure which accounts for random errors in a data set. Relative accuracy has also been referred to as the point-to-point accuracy. The general measure of point-to-point accuracy is an evaluation of the random errors (systematic errors and blunders removed) in determining the positional orientation (e.g. distance, azimuth) of one point or feature with respect to another.

Relative Horizontal Accuracy - Relative horizontal accuracy is a measure of the point-to-point horizontal accuracy within a specific data set. This measure accounts for the random errors. To determine relative horizontal accuracy, the horizontal distance between two points is measured and then compared to the corresponding measure on the reference. The difference in the measures represents the relative accuracy. It may be more meaningful to report the relative horizontal accuracy of the source material.

Resample - the use of mathematical values on one cell-based structure based on values originally given on another structure. Methods include interpolation and extrapolation. See nearest neighbor, bilinear interpolation, and cubic convolution.

Resection, photogrammetric - determination of the location or height of a camera or of the photograph taken by that camera with respect to a coordinate system external to the camera.